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Micro- and Macro-Fluid Dynamics and Acoustics of Resonant Liners

submitted by

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Summary of Research
Grant NAG 1-1986

The objectives of this project are :

1. To perform direct numerical simulation of the micro-fluid and acoustic fields of a resonant acoustic liner.

2. To investigate the physical processes by which incident sound waves are damped by the acoustic liner

We would like to report that our research work and results (supported by this grant) have fulfilled both objectives of the grant. The following is a summary of the important accomplishments.

a. Two dimensional direct numerical simulation of the flow and acoustic field around the cavity of resonant liner were successfully carried out.

b. The simulations of (a) were extended to include a laminar grazing flow.

c. The numerical simulations provided strong evidence that there are 2 principal mechanisms by which a resonant liner damps out an incident acoustic wave. At low SPL, damping is achieved by viscous dissipation associated with an oscillatory fluid layer adjacent to the walls of the opening of the cavity. At high SPL (also depending on the sound frequency) the main mechanism of damping is the transfer of acoustic wave energy to micro-vortices shed at the mouth of the resonator. The shed vortices are eventually damped out by molecular viscosity. No oscillatory turbulent jet at the mouth of the resonator was observed in all the simulations even at SPL as high as 160 dB. This is somewhat contrary to traditional thinking of liner dissipation mechanism.

d. A validation test was performed by comparing the computed dissipation coefficients (not impedance) with impedance tube measurements done at GTRI.

e. Some resources of this grant were used to support the development of new CAA methods. (Our work on numerical simulation of acoustic liners has benefited by the availability of these improved methods).

Publications supported by the grant.

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2. Tam, C.K.W. and Kurbatskii, K.A. *A wavenumber based extrapolation and interpolation method for use in conjunction with high-order finite difference schemes* , Journal of Computational Physics, **157**, 588–617, 2000.

3. Tam, C.K.W., and Aganin, A. *Computation of transonic nozzle sound transmission and rotor problems by the dispersion-relation-preserving* scheme. Proceedings of the 3rd CAA Workshop on Benchmark Problems, pp 191-202, NASA CP-2000-209790, Aug 2000.

4. Kurbatskii, K.A. and Tam, C.K.W. *Micro-fluid dynamics of a resonator in a grazing flow.* AIAA paper 2000-1951.

5. Tam, C.K.W., Kurbatskii, K.A., Ahuja, K.K. and Gaeta, R.J. *A numerical and experimental investigation of the dissipation mechanisms of resonant acoustic liners* (with K.A. Kurbatiskii, K.K. Ahuja & R.J. Gaeta) Journal of Sound and Vibration, **245**, 545-557, 2001

6. Tam, C.K.W. and Kurbatskii, K.A. *Multi-size-mesh multi-time-step Dispersion-Relation-Preserving scheme for multiple scales aeroacoustic problems.* AIAA paper 2002-0224. To appear in the International Journal of Computational Fluid Dynamics, 2002.